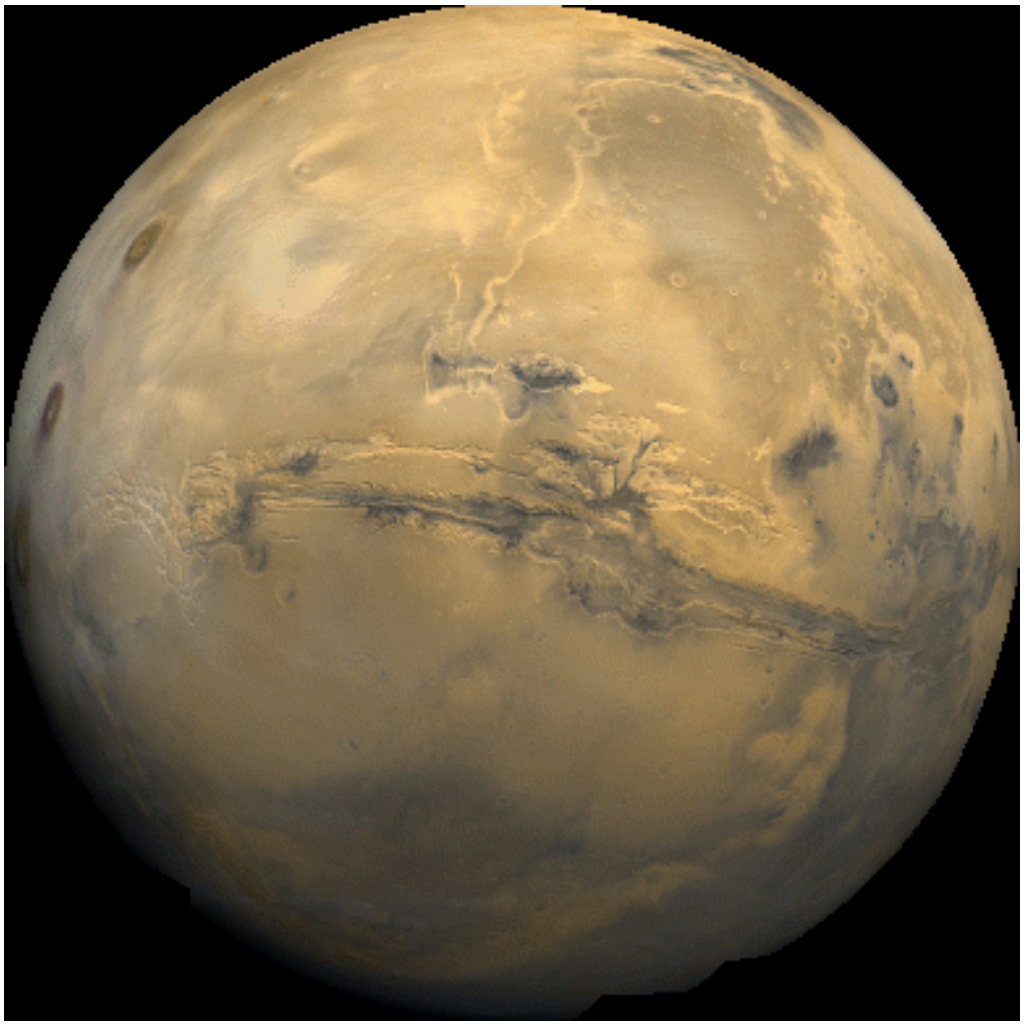
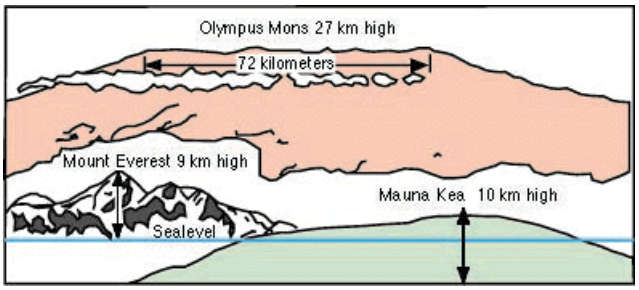
MARS



Lesson 4 - Comparing Martian Volcanoes to Terrestrial Volcanoes: Olympus Mons vs. Hawaii

USGS
science for a changing world
Astrogeology Research Program



Comparing Martian Volcanoes to Terrestrial Volcanoes: Olympus Mons vs. Hawaii

Grade Level: 7th –12th

Objectives:

- Conduct an experiment to test a hypothesis
- Construct models of Hawaiian volcanoes and Olympus Mons volcano
- Compare/contrast the two models
- Interpret data from experimental results and judge whether or not it supports an initial hypothesis
- Distinguish between different styles of volcanism
- Identification of the components of a shield volcano

Arizona State Standards:

- **1SC-P2.** Compare observations of real world to observations of a constructed model. **PO 1.** Assess the capability of a model to represent a "real-world" scenario.
- **6SC-P3.** Use the theory of plate tectonics to explain relationships among Earthquakes, volcanoes, mid-ocean ridges and deep-sea trenches. **PO 2.** Describe the relationships among Earthquakes, volcanoes, mid-ocean ridges, deep-sea trenches and tectonic plates.

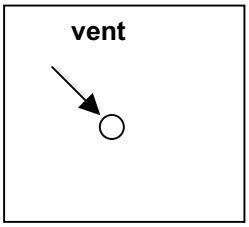
Time Needed: 1class period

Background:
Scientists believe that the large volcanoes of Mars are composed of basaltic magmas much like the Hawaiian Island chain on Earth. The Tharsis region on Mars is known for its extremely large **shield volcanoes**. Olympus Mons is the largest volcano in the solar system with a diameter of 600 km (374 miles) and a height of nearly 25 km (~16 miles). Olympus Mons is as wide as the state of Arizona. The great size of these Martian volcanoes is most likely caused by the lack of **plate tectonics**. During the length of their eruptive history, magma extruded from a stationary source and the erupted lavas continued to pile up on themselves in the same location. Conversely, on Earth, even though the magma source from hot spots remains in the same location, the overlying **lithospheric plates** are constantly moving resulting in an island chain such as the Hawaiian Islands and Emperor seamounts in the Pacific Ocean.

Materials:

- Medium viscosity substance in a tube, such as toothpaste (provided) or hair gel. (Even though basaltic lava has a low viscosity, for the purposes of this experiment we don't want a **big** mess so stick with a medium viscosity substance)

- 2 pieces of cardboard for each group, one rectangular with 5 holes in a line down the center (Figure 1) and one square piece with a single hole in the middle (Figure 2) (provided)
- Stopwatch
- Paper towels
- Ruler (provided)
- Unopened liter of dark soda (provided)
- Opened liter of dark soda (provided)



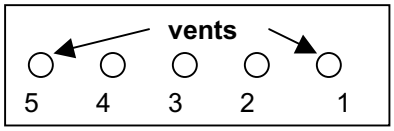


Figure 1. Cardboard model of Hawaiian Islands

Figure 2. Cardboard model of Olympus Mons

Discussion/Demonstration:
Show *Overhead 1*, an oblique global view of the planet Mars showing the Tharsis volcanoes. Point out the circular features and ask the class if they know what these are. Volcanoes with broad, gentle slopes built by the eruption of fluid basalt lava are called shield volcanoes. Show *Overhead 2*, cross-sections of a shield volcano, to allow students to see the structure. Point out the **central vent**, **lava flow**, **magma chamber or reservoir**, and **summit caldera**. Show *Overhead 3* of Olympus Mons. Ask what this feature is. Explain that it too is a basaltic shield volcano much like the volcanoes that make up the Hawaiian Islands. Point out morphologic parts of the volcano – **calderas** on top, **lava flows**, **rifts**, **basal scarp**, and landslides or slumps found on and around the volcano sometimes called **aureole deposits**. Make sure the class is aware of the image scale. Display *Overheads 4 and 5*, which compare the size of Olympus Mons with Hawaii both in plan view and in cross-section. Mauna Loa is the tallest mountain on earth, and is also a very large shield volcano. (Explain that both of these volcanic areas erupt effusively (rather quietly) and have students compare differences in dimensions and morphology between Olympus Mons and Mauna Loa. Show *Overhead 6*, Olympus Mons superimposed on the state of Arizona and the Tharsis region vs. the U.S., to give students additional comparisons.

Demonstrate the difference between **explosive** and **effusive eruptions.**

- Explosive eruptions occur when a mixture of gas and water is quickly depressurized. Demonstrate by shaking an unopened bottle of soda. Walk up to a student and ask if he/she would like you to open the bottle while standing in front of them. They will most likely say no. Ask why not. Explain that soda is a combination of gas and liquid held together by pressure. Opening the bottle releases the pressure allowing the gas and liquid to rapidly separate and escape from the bottle as foam. Similarly, **magma** is also a mixture of gas and liquid under pressure. When magma reaches a planets surface, the reduction in pressure allows the gas and liquid to separate creating fountains of frothy lava.

- Effusive eruptions occur when **degassed** lava erupts. This can be demonstrated using soda that has sat around opened for a while, e.g. soda with no fizz left in it. Shake up this bottle and ask the students what will happen when you open the top? This magma gently pours out because its gas has already escaped. Usually effusive eruptions occur later in an eruptive sequence.

Activity:
The students will conduct an experiment to test the hypothesis that Mars may not have plate tectonics based on the large size of its shield volcanoes.

Procedure:

1. With *Overhead 5* showing, ask students why volcanoes grow so large on Mars, much larger than on Earth?
2. Have them brainstorm several hypotheses to explain this phenomenon. They may do this in groups or individually. Have them write their hypotheses on the board. Start a discussion of how they came up with these explanations and how they might test them.

   Some example hypotheses:
   - More magma on Mars
   - No plate tectonics
   - Longer eruptions on Mars
   - Different kind of magma on Mars
   - Volcanoes on Mars are older than on Earth
3. Explain that in this lesson they will be testing the hypothesis that volcanoes are larger on Mars because the crust of Mars is not broken into constantly moving lithospheric tectonic plates (no active plate tectonic processes).
4. Divide students into groups of four or five.
5. Each group will receive two pieces of cardboard as shown in Figures 1 and 2 above. One will have 5 holes punched in a line down the center and the other will have one hole punched in the center. The 1st strip will be used to create a chain of volcanoes similar to the Hawaiian Islands and the square piece will be used to create a large shield volcano similar to Olympus Mons on Mars.
6. Students will create model volcanic edifices by simulating the eruption of magma (viscous substance) onto the surface (cardboard). Students will SLOWLY squeeze magma up through the holes in their cardboard for a set amount of time.
7. Each group will divide into two subgroups. One subgroup will simulate Hawaiian Islands eruptions (Figure 1) and the other subgroup will simulate Olympus Mons (Figure 2).
8. One person per group can be timekeeper or the entire class can do each trial at the same time with the teacher timing the eruptions.
9. Each subgroup will simulate 5 eruptions, each eruption lasting a set amount of time. In all cases keep the magma source stationary. The Hawaiian subgroup will move their cardboard from vent to vent for each eruption keeping the magma source stationary. Eruptions must start from one end of the cardboard and work their way to the other end, going from vent 1 to vent 5. The Olympus Mons subgroup will extrude the substance into the same central vent for each eruption.

SubGroup Procedures:

For Hawaiian Islands Model:
Five different vents
Vent 1= 10 seconds
Vent 2= 10 seconds
Vent 3= 20 seconds
Vent 4= 25 seconds
Vent 5= 45 seconds

For Olympus Mons Model:
Single Vent
1st time= 10 seconds
2nd time= 10 seconds
3rd time= 20 seconds
4th time= 25 seconds
5th time= 45 seconds

Closure/Assessment:

Once the experiment is finished, have subgroups meet in their original group of 4 or 5 students and discuss similarities and differences between the two models for about 5 minutes. Then, have all of the groups who simulated Hawaii gather together and compare and contrast their models for another 5 to 10 minutes. Did they have the same results? How did the size, shape, and height of their volcanoes differ and how were they alike? Have the groups that simulated Olympus Mons gather together and discuss their results. Have them talk about how their models were different and how they were similar. Discuss how plate tectonics affects volcano building. While, they are meeting in these groups, have the students answer the questions on the **Student Question Sheet** and collect the sheets for assessment.

Vocabulary:

Shield volcano, plate tectonics, lithospheric plates, degassed, central vent, lava flow, magma chamber or reservoir, summit caldera, calderas, rift, basal scarp, aureole deposit, explosive eruption, effusive eruption

Additional Resources:

- http://volcanoes.usgs.gov/
- http://wwwhvo.wr.usgs.gov/
- http://www.volcano.si.edu/world/region.cfm?rnum=02&rpage=list
- http://www.windows.ucar.edu/tour/link=/earth/interior/shield_volcanos.html
- http://volcano.und.nodak.edu/vw.html
- http://wapi.isu.edu/EnvGeo/EG6_volcano/volcanoes.htm
- http://www.uwsp.edu/geo/faculty/ritter/images/lithosphere/volcanism/hotspt.jpg
- http://www.uwsp.edu/geo/faculty/ritter/geog101/lectures/lecture_volcano.html
- http://planetaryexploration.net/jupiter/io/photoglossary/shield_volcanoes.html
- Duffield, W. A., Volcanoes of Northern Arizona, Grand Canyon Association, AZ, 1997.
- Mursky, Gregory, Introduction to Planetary Volcanism, Prentice-Hall, Inc., Upper Saddle River, NJ, 1996.

Student Question Sheet

Name_____

1. While in your main group, use the ruler provided to measure the approximate diameter and height of each of the volcanoes your group created. Fill in the chart below.

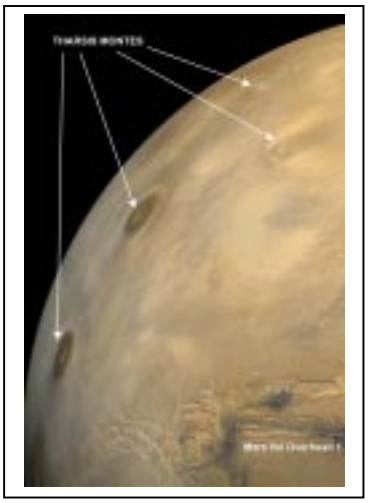
	Olympus Mons	**Hawaii vent 1**	**Hawaii vent 1**	**Hawaii vent 1**	**Hawaii vent 1**	**Hawaii vent 1**
Diameter of volcano						
Height of volcano						

2. Describe the differences in height, diameter and shape between your group's model of the Hawaiian Island volcanoes and the model of Olympus Mons.

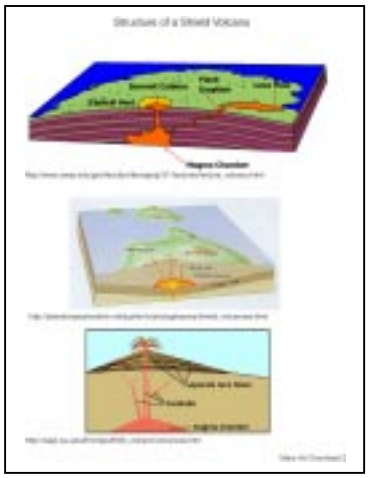
3. Look at your group's and several other group's model of the Hawaiian Islands. Was there a relationship between the amount of time the magma erupted from a vent and the size of the volcano it created?

4. Judging from your group's models was the hypothesis you tested supported by your experiment or not? Explain your answer.

Overheads



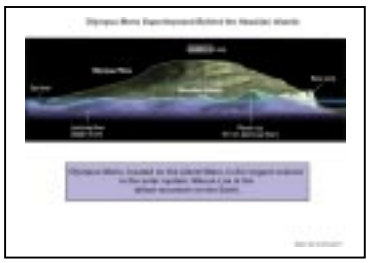
Overhead 1. The Tharsis Montes, Mars.



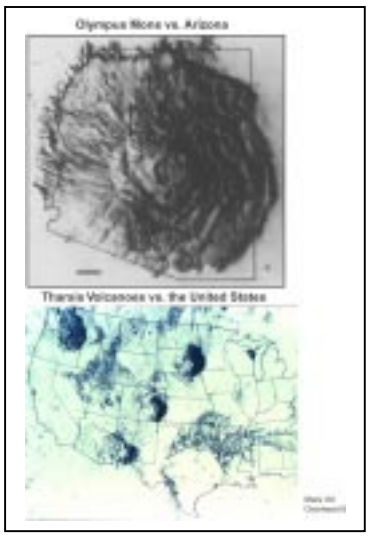
Overhead 2. Parts of a shield volcano.

Overhead 3. Olympus Mons, Mars.

Overhead 4. Olympus Mons vs. the Hawaiian Islands.



Overhead 5. Profile comparison of Olympus Mons and Mauna Loa.



Overhead 6. Olympus Mons compared with Arizona and the United States.